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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: D.5.4/D.5.5

Sweden

NEW TECHNIQUES IN THE PROCESSING OF VEGETABLE OILS AND FATS OF SPECIAL INTEREST FOR TROPICAL AREAS

By Ben BRAAE,
Licentiate in Technology

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NOTES

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No.1762 New Techniques in the Processing of Vegetable Oils and Fats of Special Interest for Tropical Areas

D.5.4./D.5.5.

by Ben Braae, Licentiate in Technology

Several kinds of oliferous plants are indigenous to tropical areas. The fruits of these plants contain considerable amounts of vegetable oils or fats which can be used not only for edible purposes but also for many technical applications, for instance, as raw material for the manufacture of soap. Typical examples of such fats are coconut oil, palm oil, palm kernel oil and groundnut oil and there are many others.

(a) Recovery of Oil or Fats from Natural Oliferous Material

Obviously the methods used for recovering oil or fat from the fruit of oliferous plants will depend on the kind of the fruit, its size, the thickness and the mechanical characteristics of the shell as well as on the oil content of the raw material, and the kind of non-fatty material from which the fat has to be extracted.

In the case of coconut oil, the shell of the nut is first opened by hand or by a special machine and the fruit meat then dried over open fire or in specially constructed ovens. This gives a product called copra which with a low water content and good keeping qualities can easily be stored and transported. The low water content is of great importance because all fats are subject to hydrolysis when water is present, thus forming free fatty acids, which may influence the suitability of the fat for nutritional purposes, and which in any case will give rise to big losses during the refining operations necessary to produce an edible oil of good quality.

The oil is recovered from the copra by mechanical pressing or by solvent extraction or by a combination of both methods. For many years hydraulic presses were used for the recovery of the oil, but these presses leave a relatively great amount of oil in the cake, and require a great amount of manual labour. Modern screw presses or expellers have a higher power consumption, but need less labour and leave less than 4 per cent of oil in the cake. A method which nowadays has achieved widespread application is the recovery of the oil from the cake by means of solvent extraction. A hydrocarbon, usually hexane, is used for this purpose and the yield of oil is very high. The oil content of the cake is always lower than one per cent and in many types of extraction plants is considerably lower. However, solvent extraction plants are relatively expensive as distillation equipment for the recovery of the solvent must be included and as special precautions must be taken in order to avoid losses of expensive solvent as well as the risk of fire.

Depending on the type of raw material as well as on the cost of electric power, steam, etc. it is often a sound economic proposition to combine the mechanical expelling method for the recovery of the fat with the solvent extraction method. As the yield of oil obtained by expeller per hour, it is obvious that a high yield of oil can only be obtained at a high investment cost and a high power consumption per unit of oil produced. However, if the throughput of the meat through the expeller presses is increased the unit cost per ton of oil is considerably reduced, even if the yield of oil is also reduced. On the other hand, many types of solvent extraction plants

do give the most economic results, and the highest oil yields, when the amount of oil contained in the meat is not too great. Thus the optimal economic result is often obtained by a combination of mechanical expelling and solvent extraction of the seeds.

Special treatment of the oil seeds such as milling, rolling, etc. is necessary in order to obtain high oil yields, but these treatments will vary with the kind of seed and cannot therefore be discussed in detail. For the recovery of oil from palm kernels and groundnuts methods very similar to those described for the recovery of oil from copra are used. The oil cakes from the expeller presses as well as the meat from the solvent extraction plants have a considerable value as cattle fodder. It has been found that the nutritional value of the cakes depends mainly on the protein content and hardly on the amount of fat remaining in the cakes. From an economic point of view it is therefore of advantage to leave as little fat as possible in the cakes.

In the case of palm oil a somewhat different treatment must be applied due to the different characteristics of the raw material. The red palm oil is contained in the fruit meat surrounding the kernels of the fruit of the palm tree. This fruit meat is boiled in water, often autoclaved at a temperature above 100°C (212°F), thus liberating the oil from the fruit meat. The bulk of the fruit meat is then removed by screening and by special centrifuges capable of removing solid matter from the suspension of oil in water. The oil and the water are then separated by means of specially constructed centrifuges, leaving a minimum of oil in the drabwater. The oil thus obtained will usually still need another centrifugal purification in order to remove the last traces of water and impurities.

The fruit meat of the palm fruit contains a lipolytic enzyme which provokes a very rapid hydrolysis of the palm oil. It is therefore of the utmost importance that the autoclevation of the fruit meat is carried out as soon as possible after the fruit is gathered if serious deterioration ot the palm oil is to be avoided.

(b) Alkali Refining of Vegetable Oils

In some countries crude vegetable oils, produced as described above are used directly for human consumption. However, modern requirements regarding keeping qualities and organoleptic properties of the oil necessitate that these crude oils be subjected to a number of chemical treatments. The first of these treatments is the alkali refining.

The alkali refining of fatty oils aims at the removal of constituents other than glycerides, such as free fatty acids, phospahatides and pigments, which render the unrefined oils more or less unfit for human consumption and unsiutable for technical purposes.

Of all known methods of refining treating the oil with caustic soda is that most generally used, the reason being that not only the fatty acids but also other substances which must be removed to produce an oil of adequate quality are attacked by the lye.

Traditionally the alkali refining of fatty oils has been by the batch method in big tanks containing from 5 to 50 tons of oil. However, considerable losses of neutral oil are involved by this

method. Due to the long contact time between oil and lye (usually between 15 and 30 minutes) inherent in the batch process any excess of lye necessary to remove gums and coloured matter is almost entirely consumed in the saponification of neutral oil.

In the continuous refining process the contact time between oil and lye may be reduced to a few seconds, the losses of neutral oil being correspondingly reduced.

Centrifugal separators have made it possible to cange over from batch to continuous processing in the refining of fatty oils. Caustic soda is continuously mixed with the oil, the free fatty acids as well as other impurities reacting with the alkali forming a by-product known as soapstock. In modern continuous plants the ratio between oil and caustic soda is kept constant and independent of the oil flow. In the centrifuge the oil is continuously separated from by-products, such as soapstock, wash water, etc. (See Figure I).

In all types of continuously operating separator bowls it is necessary to adapt the position of the boundary zone between the two phases with reference to the difference in their specific gravities. When using conventional "open type" separators this is effected by interchangeable regulating disks, past which the heavy component leaves the bowl. However, the regulating disks cannot be changed during operation as the bowl must be stopped every time it is desired to alter the boundary zone. In modern separators of the hermetic type the position of the boundary zone and thus the separation result can be altered while the separator is in operation by using a throttle valve to vary the back pressure in the outlet line. (See Figure II).

In a hermetic separator the mixture of oil and soapstock is introduced to the bowl under pressure through the hollow rotating separator spindle. This constitutes a very mild treatment of the reacting material and reduces the risk of particle break-up and emulsification. Both the inlet and the outlet of the hermetic separator are fitted with axial seals, which prevent the oil from coming into contact with air.

Modern continuous refining processes comprise a treatment with citric or better still phosphoric acid prior to neutralisation. These acids attack phospahatides present in the oil, reduces the tendency for emulsification (thus reducing the losses), and improves the organoleptic properties of the oil. The acids are neutralised together with the free fatty acids.

Some oils, but not those mentioned here, may need further alkali treatment in order to improve the colour and the quality.

The neutralised oil is finally washed with hot water in order to remove the last traces of soap and the oil is finally dried in vacuum.

When using hermetic separators the continuous refining plant is in fact a completely closed system, where the oil has no contact whatsoever with the air from the moment the crude oil is pumped into the plant until the refined and dry oil leaves the drying section. Consequently no oxidation of the oil takes place during the refining operation, and a refined oil having excellent organoleptic properties as well as a high stability during storage is obtained.

The reason why the conventional batch refining plants nowadays are being rapidly replaced by continuous plants may be summarised as follows:

(i) The continuous refining plant is extremely easy to operate and takes up very little space. The somewhat higher capital cost of a continuous plant as compared with batch plants is offset by a corresponding reduction in building costs. Running costs and maintenance expenses for the continuous plants are low.

(ii) Continuous refining plants are extremely flexible and the same plant can be used for refining all kinds of fatty oils with the exeption of castor oil.

(iii) Due to the short reaction time between oil and lye and to the efficient separation of the oil from the by-products obtained when using separators, especially of the hermetic type, refining losses are very low. Thus the initial investment cost of a continuous plant is very quickly recovered.

(iv) There is a considerable improvement in the quality of the refined oil as compared with that produced by older refining methods, due partly to the phosphoric acid treatment which completely removes all traces of phosphatides, and partly to the hermetically closed refining system which completely prevents any deterioration of the oil by oxidation. With alkali refining of fatty oils a by-product called soapstock is obtained. The soapstock contains the sodium salts of the free fatty acids contained in the crude oil as well as water and certain minor impurities, mainly gums. The soapstock obtained when refining the kind of oils dealt with here, is of relatively good quality, because the amount of impurities and especially coloured material is relatively low. Consequently the soapstock may be used directly as a raw material for soap-making, especially if it is a question of producing only laundry soap or industrial soaps.

However, if high-grade toilet soap is required, it is necessary to purify the soapstock. In such cases the soapstock is treated with sulphuric acid and a product called "acid oil" is obtained; this consists mainly of fatty acids containing some neutral oil. The acid oil is practically water-free and the transport costs involved with this product are consequently lower than for soapstock, a fact which is of great importance. However, the acid oil is still not pure enough to be used as a raw material for high-grade toilet soaps and is therefore usually further purified by means of vacuum distillation. In this way distilled fatty acids, which fulfil high quality soap-making requirements, are obtained.

(c) Further Refining Treatments: Bleaching, Deodorisation, Winterising, Hardening

The alkali refined oils are still not suitable for human consumption, as they contain certain coloured substances as well as odiferous matter, which must be removed.

The alkali refining is therefore followed first by a bleaching

process and then by deodorisation. The purpose of the bleaching process is to remove coloured matter; this is done by mixing the oil with bleaching earth - preferably activated. The bleaching is usually carried out in batch containers, the bleaching earth being thoroughly mixed with the oil. The temperature is usually about 100°C (212°F) and the contact time approximately 20 - 30 minutes. The bleaching earth is then removed from the oil by filtration.

The oils mentioned here are relatively easy to bleach and only a small amount of bleaching earth, usually less than 0.5 per cent, is necessary. Palm oil is an exception as the red colour (carotenoids) is not easily removed by the treatment with bleaching earth. Higher temperatures and blowing with air is therefore sometimes used, but this treatment has a deleterious effect on the oil. Other oils, for instance cottonseed oil, have a much darker colour, and the amount of bleaching earth necessary is therefore much greater.

Even the bleached oils have a characteristic flavour which is objectionable in most cases if the oils are to be used for human consumption. This flavour is due to the presence of very small amounts of odiferous matter, which are removed by blowing steam through the oil. This process is known as deodorisation, a process which can be carried out both by the batch method and by continuously working equipment. The last-mentioned method is especially suitable if relatively great quantities of oil - say, approximately 50 tons a day - have to be treated. Continuous deodorisers effect a considerable saving of steam as compared to the batch deodorisation. The steam blowing is carried out at temperatures between 180°C - 220°C (356°F - 428°F), depending on the type of oil to be deodorised, the holding time, and the material of which the deodoriser is made. The lower temperature is mainly used in batch deodorisers constructed of ordinary mild steel, whereas the higher temperature is used in continuous deodorisers, having a much shorter holding time, and usually being constructed of stainless steel. The time of steam blowing, and thus the steam consumption, varies very much with the kind of oil to be deodorised. The oils mentioned here are relatively easy to deodorise but other oils, such as soyabeen oil and rape seed oil, need much more through treatment in order to give a satisfactory result.

When used as salad or cooking oil it is desirable that the oil keeps clear. Some oils, for instance cotton seed oil, sunflower seed oil and certain others, contain waxes which precipitate at room temperature. These waxes may be removed by a process known as winterising, by which the oil is cooled down to such a temperature where the waxes crystalise. They are then removed by filtration and a clear, brilliant oil is obtained. The melting point of a given fat is a characteristic which has an important bearing on the use of the fat in question for manufacturing marketable products. When making salad or cooking oil a fluid oil must be used. For the manufacturing of margarine or shortening fats with higher melting points must be chosen. Fortunately the oil technician has at his disposal a method to produce fats of any desirable melting point. This process is called hydrogenation or hardening. The startening material for this process is fluid oil, for instance groundnut oil, cotton seed oil, fish oil, etc. Such oils are reacted with hydrogen in the presence of a suitable catalyst. By this treatment the melting point of the oil is raised to any desired value. Due to the

fact that natural fats with high melting points, such as coconut oil, are in great demand, not only for human consumption but also as raw material for many industrial products such as soap, the hardening process gives the manufacturers of edible products such as margarin a big liberty in the choice of raw materials.

(d) Marketable Products in the Edible Oil Industry

For climatic and traditional reasons the human consumption of natural fats for centuries has been divided mainly in three different groups: butter, olive oil and lard. As the supply of these natural fats is not sufficient to satisfy the steadily increasing consumption, the modern edible oil industry has concentrated on manufacturing products which closely resemble the traditional ones, but which could be manufactured from more easily available raw materials.

Margarine is consequently produced as a substitute for butter, fluid oils such as groundnut oil, soya-bean oil, sunflower seed oil as a substitute for olive oil, and shortening as a substitute for lard.

When alkali refined, bleached and deodorised, possibly also winterised, fluid oils can be used as salad or cooking oil.

The manufacture of margarine is somewhat more complicated. Apart from flavour, keeping qualities, colour, etc., the most important property of margarine - as well as that of butter - is its plasticity or spreadability. These properties can only be obtained when fats of different melting points are used in the production of margarine. The fats used are refined as described above and a fat blend consisting of oils with different melting points is then prepared. The composition of the blend will depend on the climatic conditions in the country of consumption and on the type of margarine to be produced. Natural fluid oils are mixed in appropriate proportions with fats having higher melting points; these are often obtained by hardening of liquid fats.

The other main ingredient of margarine is skimmed milk, and there are the minor ingredients such as emulsifiers, vitamins, colouring matter, etc., which may also be added. These ingredients are throughly mixed at a temperature where all are liquid, usually approximately 50°C (122°F), and special emulsifying machines are used so that the skimmed milk forms small drops in the fat mixture. The emulsion is then rapidly cooled down on chilling drums or pressure coolers and the solidified mass packed.

It should be mentioned that margarine has a big sale, not only for direct human consumption, but also for the bakery industry.

The third main product manufactured for edible purposes from fatty oils is shortening. Shortening is pure fat with no water content and a relatively high melting point. As is the case with margarine, fats of different melting points are mixed together in order to obtain the desired plasticity. Shortening is used for frying purposes and is also widely used in the bakery industry, for instance in making biscuits.

(e) Soap-making

Some of the fats mentioned here are also important raw materials for soap-making. Marketable soaps can be divided into three groups:

high quality toilet soap, laundry soap, and industrial soaps. The quality requirements for the raw materials used to manufacture toilet soap are, of course, the highest, a mixture of tallow and coconut oil being the best, However, for coconut oil it is possible to substitute palm kernel oil, while to some extent palm oil can be substituted for tallow, especially if the amount of coconut oil is reduced.

For the other types of soaps many other fats as well as soapstock or fatty acids from soapstock may be used.

(i) Soap-making from Neutral Fats

A neutral fat is a chemical composition of fatty acids and glycerol. In the saponification process the fat is reacted with caustic soda, thus forming sodium salts of fatty acids (soap) and free glycerol. In conventional soap-making this process is carried out in batch, a tedious and time-consuming operation, because the saponification must be complete if the keeping quality of the finished soap is to be good.

As the glycerol is a very valuable by-product, the recovery of which is of great economic importance for a soap factory, the saponification operation is followed by a number of washings in brine. After each washing the spent lye is decanted from the soap and drawn off. The spent lye is then concentrated by distilling the water, the glycerol finally being distilled in a vacuum in order to obtain a high quality glycerol.

When making high grade toilet soap, the soapmass usually undergoes a fitting operation, where the mass is divided into neat soap and niger. The niger contains the bulk of impurities such as coloured material, oxy-fatty acids, etc., the presence of which is harmful to the quality of the soap. The neat soap, on the other hand, possesses the best possible physico-chemical properties for the further treatment of the soapmass. The niger and the neat soap is then decanted and the niger drawn off, while the neat soap is going for further treatment. When using the old batch process, this whole procedure may take an entire week, a considerable amount of capital thus being tied up during this time. Furthermore, the steam consumption for keeping the soapmass at the desired temperature throughout so long a period and the success of the operation depend very much on the personal skill of the soapboiler. With the batch process large amounts of scrap, which must be reworked, are easily formed.

In order to avoid these difficulties, continuous processes for soap-making have recently been developed. Here the saponification is carried out in special reaction columns, where lye and oil are intimately mixed, whereby the reaction velocity is increased many times. By means of completely automatic control devices the proportions of oil and lye are kept constant, thus avoiding both the use of an unnecessary and costly excess of lye, and an incomplete saponification reaction which may be harmful to the quality of the finished soap. The soap-making process is thus completely independent of the skill of the individual soapboiler. (See Figure III). The washing of the saponified mass for recovering the glycerol is also carried out continuously by means of centrifugal extractors. The washing with brine is carried out in counter current; this gives a high yield of glycerol aswell as a high concentration of glycerol in the spent lye. Both these factors affect the economy of the glycerol recovery to a considerable extent.

Also the fitting operation may be carried out continuously in modern plants. As the difference in specific gravity between the neat soap and the niger is small, the separation of the two soap phases is difficult. However, the hermetic separator as described above is especially suitable to deal with the problem in question and a complete separation of the phases formed in the fitting operation can be obtained.

The advantages obtained by a continuous soap-making process may be summarised as follows:

(a) The time necessary for producing a soapmass is reduced from nearly one week to one hour;

(b) a considerable reduction in space requirements and consequently in building costs;

(c) a very large saving in steam consumption;

(d) complete automatic control and consequently avoidance of formation of scrap; this involves considerable saving.

(ii) Soapmaking from Fatty Acids

As already mentioned, fatty acids obtained from soapstock as well as from other sources may be used as a raw material for soapmaking. Fatty acids may also be obtained directly from neutral fats by hydrolysis. The operations thus involved are first the production of fatty acids from low grade fats or acid oil, the purification of the fatty acids by vacuum distillation, and the production of soap from the fatty acids,

It is obvious that this sequence of operations gives the soapmaker a great liberty in his choice of raw material, because low grade raw material can be upgraded through the distillation of fatty acids. Another advantage is that working up of the "sweet water" obtained by hydrolysis of low grade fats is much easier than the recovery of glycerol from the spent lye containing salt.

On the other hand, both the investment costs, and the running costs for plants, which first split low quality fats into fatty acids and glycerol and then produce soap from the fatty acids are much higher than the costs for a plant which makes soap directly from neutral fat. The obvious reason is that the many different operations involved in the first method require considerable investment costs, and that the running costs, especially the steam consumption for the hydrolysis of the fat and the distillation of the fatty acids, are much higher than the costs involved in the direct manufacture of soap from neutral fats.

When fatty acids are used as a raw material for soapmaking, the soap-making plant itself is, of course, considerably simplified, as the washing for the recovery of glycerol is unnecessary. The plant thus only consists of the saponification column and possibly a centrifuge for separating the niger from the neat soap.

(iii) Finishing Operations in Soap-making

The soapmass obtained from batch or continuous plants contains maximum 68 per cent of soap and minimum 32 per cent of water. As the soap-boiling is made at approximately 100°C (212°F) the soapmass

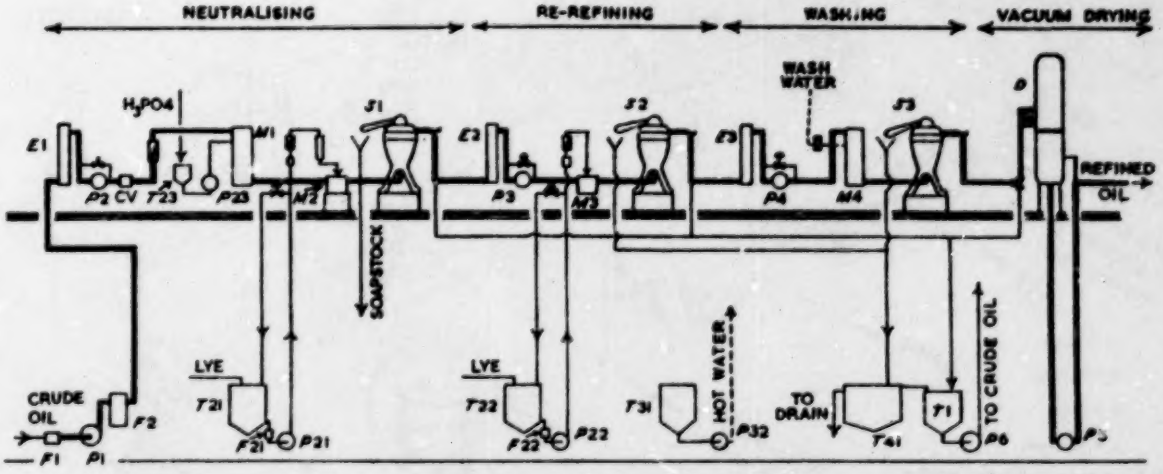
must be cooled down, and even then the water content is so high that the soap will easily dissolve.

In order to cool down the soapmass and to reduce the water content, dryers are used. Used nowadays are vacuum dryers where the soapmass is sprayed into small particles from which the water can easily evaporate. Laundry soaps are usually dried to a water content of about 35 per cent and toilet soaps to a water content of 28 per cent.

Laundry soaps may be cut and stamped immediately after drying, toilet soaps go through a number of treatments called milling, plodding and stamping. The purpose of these operations is to bring the solid soap mass into a state where the appearance of the finished tablet of soap is as pleasant to the eye as possible and where the soap does not dissolve too easily in water.

Modern vacuum driers are usually supplied with screw presses so that the dry soap is discharged as pellets. These pellets are treated in mills where perfumes, fattening agents, colouring agents, and so on are added. In order to obtain the desired physical properties of the soap, the mass obtained from the mills is treated in plodders, where a thorough mechanical treatment of the soap is carried out. Modern plodders usually work under vacuum in order to avoid any oxidation of the soap. The plodders are often built as double plodders, so that two mechanical treatments can be undertaken by the same machine. För very high grade toilet soap up to four plodding operations are usual. The soap leaves the last plodder as a bar of the desired dimension and is then cut into tablets and stamped. Finally, the tablets of soap are wrapped either by hand or by automatically working wrapping machines.

Figure I Continuous refining plant for fatty oils



F1.	Oil strainer	P23.	Proportioning pump for acid	F21, F22.	Lye strainers
P1.	Crude oil pump	M1.	Degumming mixer	P21, P22.	Lye pumps
F2.	Self-cleaning crude oil strainer	M2.	Neutralizing mixer	T31.	Water tank
E1, E2, E3.	Oil heaters	S1, S2, S3.	Hermetic separators	P32.	Process and flush water pump
P2, P3, P4.	Oil feed pumps	M3.	Re-refining mixer	T41.	Catch basin
CV.	Constant oil flow controller	M4.	Water washing mixer	T1.	Oil slop tank
T23.	Phosphoric acid tank	D.	Vacuum dryer tower	P6.	Oil slop pump
		T21, T22.	Lye tanks	P5.	Refined oil pump

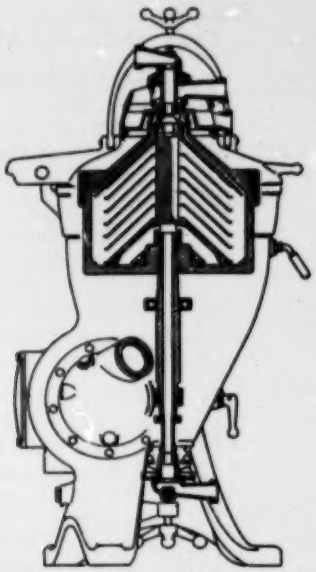


Figure II Hermetic centrifugal separator

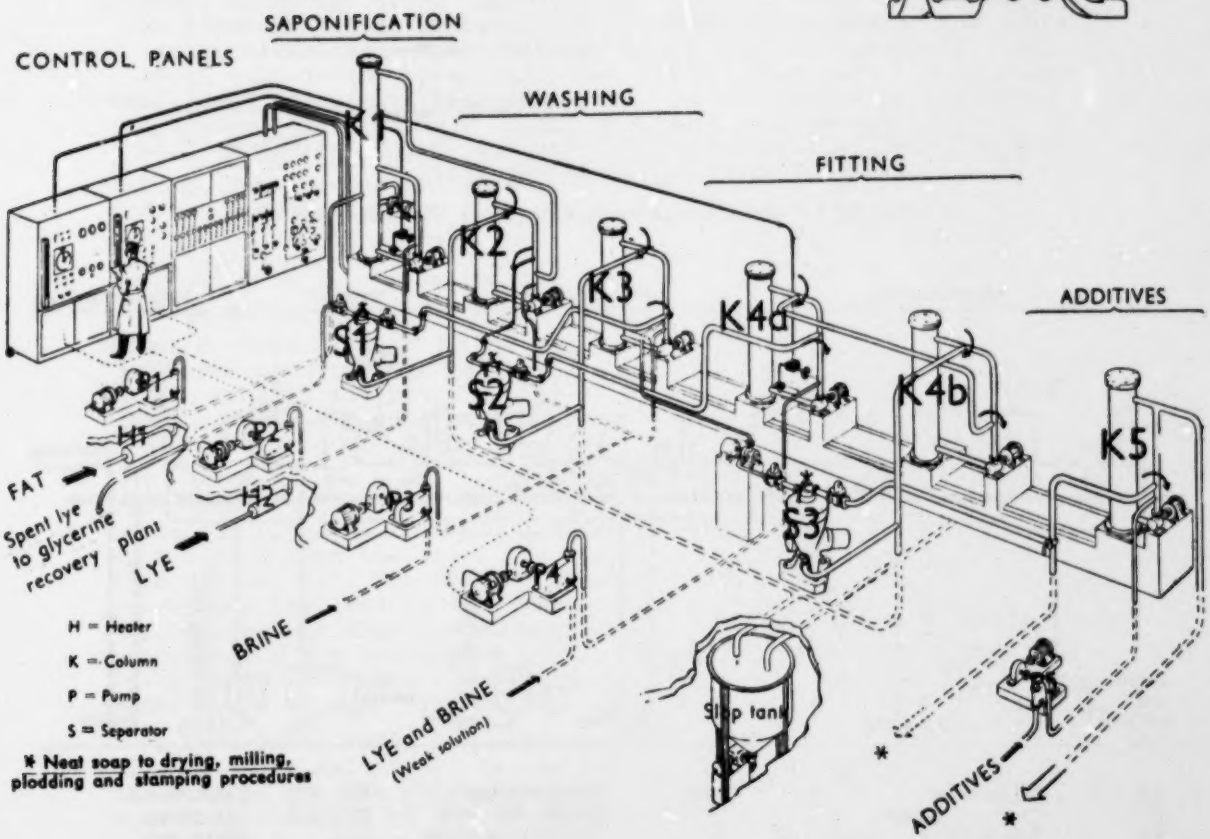


Figure III Continuous soap-making plant

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Agenda Item: D.5.4
D.5.5

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NEW TECHNIQUES IN THE PROCESSING OF VEGETABLE OILS AND FATS OF SPECIAL INTEREST FOR TROPICAL AREAS

By Ben BRAAE,
Licentiate in Technology

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NEW TECHNIQUES IN THE PROCESSING OF VEGETABLE OILS AND FATS OF SPECIAL INTEREST FOR TROPICAL AREAS

by BEN BRAAE, Licentiate in Technology

The climatic conditions prevailing in most tropical areas are especially suitable for the cultivation of several kinds of oliferous plants. Actually, the greater part of all vegetable oils and fats, which are mainly used for edible products but also have many technical applications - for instance, as a raw material for the manufacture of soap - is produced in tropical areas. Typical examples of such fats are coconut oil, palm oil and groundnut oil, but many others could be mentioned. However, up to the present the consumption of vegetable oils and fats has been greater in areas with temperate climates, and consequently large quantities of oil seeds have been exported to these areas, where the fats are extracted and processed in order to obtain marketable products. Due to the steady increase in the population of the tropical areas as well as the rising standard of living of the population, the trend in recent years has been to expand those industries which are able to produce locally marketable goods from raw materials indigenous to the tropical areas.

For the above reasons, vegetable oil refineries and soap plants are among the industries which are especially suitable for less developed tropical countries.

A short description is therefore given of modern techniques involving pressing, extraction and refining of vegetable oils and fats used to produce edible products such as salad oil, margarine and shortening. The principle of soap-making and modern equipment for the purpose is also described.

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Agenda Item: D.4.3

United Kingdom

PRESENT AND FUTURE DEVELOPMENTS IN BULK STORAGE OF PRODUCE

By F.N. WRIGHT

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Present and future developments in bulk storage of produce

by F. N. Wright

Introduction

1. At present a great deal of produce is stored in bags although, as has already occurred with many non-food materials, attention is being given to storage in bulk. Before discussing developments in bulk storage it would be useful to outline the advantages and disadvantages of bag and bulk storage.

2. The advantages of bag storage include convenience of handling by manual labour, ease of transportation by different kinds of haulage, suitability for the storage of small quantities of several separate types of produce in one building and a low capital outlay for premises. Bag storage enables simple methods of checking the quality of produce to be used and provides for a resale value of the container (the bag). Disadvantages are that bags require more storage space, they allow uptake of moisture, infestation by insects, fouling by rodents and they are costly and require the employment of a labour force which is becoming increasingly expensive to employ.

3. The advantages of bulk storage are that it requires the minimum of space, enables large quantities of produce to be handled quickly, efficiently, and with the minimum amount of labour, and eliminates the cost of bags. In addition, access by rodents can be eliminated and better protection can be given against reinfestation by insects. The main disadvantage is the relatively high capital cost of the container and ancillary equipment. Other disadvantages are that bulk storage is less easy to inspect and 'hot spots' due to breeding of insects can develop more easily.

4. Irrespective of the storage method used, in order to store produce without deterioration, certain requirements have to be fulfilled. Although grain is living and respiring, producing carbon dioxide, water and heat, if it is dry and uninfested the rate of production of these waste products is extremely low and of no significance. If grain is damp, aerobic moulds, with their very rapid rate of respiration, produce large amounts of carbon dioxide water and heat. Even if relatively dry, grain can be attacked by insects which also respire rapidly and produce large amounts of carbon dioxide, water and heat. Such damage can be prevented by drying to prevent mould growth and cooling to retard insect development. Drying is economically possible even under tropical conditions but cooling is not. In tropical countries drying is usually by means of the sun, elsewhere it is often supplemented by artificial means, being carried out by applying small volumes of very hot air or large volumes of warm air.

5. Since there is a relationship between the moisture content of a commodity and the relative humidity of the air with which it is in contact, due account must be taken of this when deciding, in a particular climate, the best form of storage to be used and the level of moisture content at which a commodity can be taken into store. Commodities vary in their equilibrium relationships with the moisture in the air and safe storage moisture contents may be low such as 6% for groundnuts or high such as 14% for paddy. These are the values of moisture content for these commodities in equilibrium with 70% relative humidity. It is only if the relative humidity of the air in contact with the produce rises above this level that moulds will be able to grow on the produce. At this level, insects can develop freely but their rate of development is progressively prolonged the drier the produce.

6. Temperature of the stored produce is important; in general terms the safe moisture contents in temperate climates are higher than those in tropical climates. Thus while a cereal grain can be stored reasonably safely at a moisture content of 14.5% in the United Kingdom, in the tropics a figure of 13% is the more usual limit.

Detection of deterioration

7. In the past the practice has been established to put produce into storage and leave it until it is required. It is important to make regular checks, e.g. weekly or fortnightly, during the storage period to ensure early detection of deterioration such as translocation of moisture and development of fungi or insects. The beginnings of deterioration problems can be inferred from certain data.

Moisture Content

8. If a product is dry, it will not be attacked by moulds or readily attacked by insects. Determination of moisture content is therefore important and should be carried out as a routine measure in all storage installations. Various rapid methods are available, and although these are usually less accurate than the slower "standard" methods, they allow more determinations to be made in a given time, so that a bulk may be more widely sampled.

Temperature

9. The production of heat by living insects has already been mentioned, thus measurement of the temperature of grain is often a good index of its condition. The presence of insects in dry grain, i.e. between moisture contents of between 11 and 15% giving rise to a temperature rise not exceeding 52°C. is known as dry grain heating. Temperature gradients may thus arise and the subsequent movement of moisture produces areas of higher moisture content. Heating of grain can also be caused by 'damp grain heating' which occurs in grain of moisture content exceeding 15% which can develop in damp grain even in the absence of insects; usually the moisture content is 17 or 18% and the maximum temperature is likely to exceed 42°C; usually a temperature of 50 - 52°C is reached (1). This kind of heating is due to the presence of moulds; a frequent sign of this kind of deterioration is caking of the grain, e.g. under metal manholes where a drop in temperature can lead to condensation.

(1) Oxley, T.A., The scientific principles of grain storage. Northern Publishing Co. Ltd., Liverpool (1948).

In bulk storage it is important to measure temperatures of the bulk, particularly, change in temperature. This can most conveniently be done by a permanent temperature measuring or recording installation. Sometimes, however, it is more practical to insert temporary devices, often using thermocouples or thermistors, in regions where deterioration is suspected.

Carbon dioxide

10. The production of carbon dioxide by insects can also be used as a means of detecting their presence by the so-called carbon dioxide method (2). This depends on the fact that in a sample of grain the insects present, although representing only a fraction of the weight of the sample, produce very much more carbon dioxide than the grain itself. If a sample of grain is incubated for 24 hours at 25°C and the concentration of carbon dioxide in it estimated by a gasometric method, so-called carbon dioxide figures can be produced which are a measure of the amount of insect infestation present. Thus a figure of 1% carbon dioxide would indicate that a heavy insect infestation was present. This method is most useful in detecting 'hidden' infestation i.e. where insects are present inside the grains and not seen by the human eye.

Examination for insects

11. By far the most common method of assessing insect infestations is the actual finding of insects on the bulk, or at the outlet spout or in a sample. Surface infestations can be detected by examination of the grain surface, walls and ceilings of the bin. Apart from seeing any live insects, evidence of their presence may be gained from such signs as webbing produced by the larvae of moths. Surface examination should be supplemented wherever possible by the taking of samples deeper in the grain; for this purpose deep sampling spears (tubes with compartments) may be used. It should be borne in mind that the detection of living insects in a bulk of grain may be very difficult if there is a very light infestation, and also that the sample examined represents a very small fraction of the total bulk. Infestations can therefore be missed. It is advisable not to rely on any one method for the detection of insects but to use a combination of the methods indicated.

Traditional storage structures

12. The simplest type of bulk storage is in a heap on the floor of a building. This is called flat storage because the length or width of the pile is greater than its height; it is to be contrasted with upright storage usually associated with bins where the height generally exceeds the length or breadth of the bulk. With flat storage, normally the produce is heaped in such a way as to prevent pressure on the walls, otherwise reinforcing of the walls is necessary to withstand the lateral pressures of the bulk; bulkheads of bagged grain or wooden supports are frequently used to limit the area of a pile of grain. This method of storing grain has the advantage of cheapness and confines damage by rodents to the surface, but it presents difficulties in controlling insect infestation.

13. Generally, bulk storage is in bins which may be sited within a building or

(2) Howe, R.W. and Oxley, T.A. The use of carbon dioxide production as a measure of infestation of grain by insects. Bull. Entomol. Res., 35, 11-22 (1944).

independent of a building; in the former case they are frequently open-topped and in the latter they are roofed. In cross section, bins are usually circular, square, rectangular or hexagonal. For any given capacity and strength the cylindrical form utilises less building material and is thus the cheapest, but requires additional floor space compared with square or rectangular bins of the same height and capacity; where a double row of bins is erected, however, use can be made of the space between bins by utilising these as inter-space bins. Square or rectangular etc. bins may be designed to fit more easily into an existing building than circular ones and can also be used to form the outside wall of a building.

14. A variety of materials is available for the construction of bins. For very large installations (50 tons or more) reinforced concrete or steel are likely to be used, but for smaller bins (less than 50 tons) concrete blocks, bricks, timber, plywood, aluminium and galvanised steel may be used. The choice of material is largely influenced by the availability of local building materials and the skill of local staff for erection; if cement is available locally precast concrete blocks may be used for bins which can be erected, under supervision, by unskilled labour. Where bins have to be imported there is a choice of prefabricated metal or plywood silos which are shipped in sections and can be easily bolted together on suitably prepared foundations which must be waterproof to prevent liquid water and rising water vapour from penetrating into the commodity stored.

15. In designing bins it is necessary to consider the internal pressures which will be attained. Grain behaves somewhat like a liquid exerting both downward and lateral pressure; thus the weight of the grain is supported by both the floor and the walls. This lateral pressure, which is usually about one third to one half of the vertical pressure, increases very little once a depth of about $2\frac{1}{2}$ - 3 times the diameter of the bin has been reached, and it is because of this fact that tall bins can be built. Lateral pressure is important when determining the strength requirements of the bin walls.

16. A dual role is fulfilled by ventilated bins in which grain is not only stored but dried. In these bins heated air is blown by a fan through ducting underneath the bins which have a porous floor of some kind allowing the heated air to pass up through the produce. Another type is the radially ventilated bin which is constructed of perforated or expanded metal with a central aerating duct; this type is rarely used for storage, serving only as a drier from which the dried grain is removed to more conventional bins.

17. The individual grains of most cereals are very robust and are not affected by the great pressures occurring in tall silos and are relatively undamaged by the handling processes in and out of bins. Other commodities however are more sensitive to pressure and friction and, are liable to sustain damage, particularly during filling and emptying. With such commodities as groundnuts, soya beans (3) and cocoa beans special attention has to be paid to mechanical handling equipment and as much use as possible made of belt-conveyors and, a slow moving chain and bucket elevator used for elevation; in addition specially designed silos may be required. Cocoa beans, for instance, are relatively brittle and cannot be allowed to fall from great heights onto the floors of bins thus special devices have to be incorporated in the silos to check the free fall of cocoa beans.

(3) Holman, L.E., Handling and storage of soybeans, in Markley, K.S. (Ed.) Soybeans and soybean products, Vol. I., Interscience Publishers, Inc., New York, (1950).

These may take the form of a series of baffles which only allow beans to fall about a foot at a time; even so this repeated buffeting could damage beans in a very deep bin; thus the use of baffles should be limited to bins not more than about 45 feet deep. For deeper bins some form of spiral slide is required. Special devices may also have to be incorporated to reduce friction during unloading (4).

18. Apart from strength considerations, it is most essential that the structure be waterproof; particular attention must be paid to making foundations waterproof so that moisture is not transmitted through the plinth and into the grain. All bins should be rodent-proof and if possible they should also be insect-proof. Since the latter is very difficult to achieve, an essential feature, not easily attainable with many types of silos, is that bins should be sufficiently gastight to enable successful fumigation to be carried out. Thus ordinary bolted construction is not desirable since gas can leak out through the bolt holes. The internal walls of bins should be smooth so as to prevent harbourage of residues and insects.

New types of storage structures

19. The erection of permanent bulk storage systems needs a large capital outlay and generally once built, the bins cannot be moved, although plywood and metal bins of small capacity can, if necessary, be dismantled and erected elsewhere. There are occasions however when in some years excess harvests are produced and existing storage facilities are inadequate. In such circumstances there is a need for quickly erected portable storage structures; this need may be fulfilled by various plastic structures (5).

20. One plastic structure in which considerable interest is being currently shown for bag storage is the 'airhouse'. This consists of a flexible plastic envelope made from a base fabric of synthetic material coated with a plastic; the shape of the envelope is maintained by blowing air into it, using electrically operated or petrol-powered fans. Such a building suitably shaped to the angle of repose of grain could be used to store a heap of bulk grain. In using such a structure for the storage of grain it is envisaged that once filled with grain the fans blowing air into it could be switched off and the fabric allowed to collapse onto the bulk, when unloading is necessary the building can again be inflated. With such a building fitted with an integral floor the grain could be fumigated and reinfestation prevented by the continuous covering of the building. Tests on such a structure for the storage of bulk grain are currently being carried out at the instigation of the Pest Infestation Laboratory, Slough, England and work is also being carried out in Russia (6) and Germany (7). In Russia, for example, an airhouse holding

(4) Theimer, O.F., On the storage of raw cocoa beans in silo compartments, 1st Choc. Rev. 13, 122-126 & 162-167 (1958).

(5) Wright, P.N. and Southgate, B.J. The potential uses of plastics for storage with particular reference to rural Africa, Trop. Sci. 4, 74 - 81 (1962).

(6) Orlsen, B., Kulakovsky, A. and Prostoserdov, A., (Grain warehouses of air supported construction). Mukomol. Elevat. Promyah. 27, 14 - 16 (1961).

(7) Otto, F., Pneumatische Konstruktionen. Bauwelt, Berlin, 52, 571 - 576, (1961).

4000 tons of grain has been built and experiments are being carried out on structures supported by pneumatic arches. The use of such plastic buildings would add flexibility to existing storage systems.

21. Bulk storage at depots in overseas countries has been largely confined to the cereal grains. This is understandable since the amounts of these that are stored are far greater than for any other commodity. A most pertinent factor which influences whether or not a commodity shall be stored in bulk is that of transportation. The grain trade is so vast that special grain ships are available which can carry 10,000 tons of bulk grain. However there are few other commodities which could be shipped in similar quantities; although one hold in a ship may be devoted to carrying a commodity in bulk it is not very practicable to subdivide holds for commodities whose quantities are likely to vary on each shipment.

22. To meet these special conditions it should be possible to transport these commodities in semi-bulk containers which would be of such a size as to be lifted by a crane and of dimensions suitable for packing into holds of ships; thus, the weight of a filled container might be of the order of 15 tons. The most obvious advantage of such containers is the time saved in loading and unloading ships, thus ensuring quicker turn-round and a reduction in demurage costs and, the saving of the costs of the labour which would otherwise be used.

23. But there are greater benefits to be considered. The jute sack, commonly used at present for many commodities, is a most inefficient container in that insects have ready access to the commodity through the meshes of the sack fabric and unless an insect-proof barrier is added to or incorporated in the sack, commodities can never be maintained free of insects. An insect-proof container would thus be advantageous. In addition to this, if the container were insulated, trouble from water movement within a hold and subsequent condensation would be minimised. If the container were also gastight, its contents could be fumigated prior to shipping and they would be free of live insects on arrival in the importing country. It might also be possible to make these containers sufficiently airtight for them to act as hermetic containers.

24. It is a short step from this conception to realise that the use of bulk containers, apart from the immediate advantages at ports, could well be extended to the producing areas away from the ports. Crops, after harvesting and drying, would be put into these containers, fumigated to kill any stored products insects and thus would store without deterioration. Since these containers would be waterproof they could be stacked in the open, thus eliminating the need for storage premises.

Control of insect pests

25. In hot climates, in particular, certain species of insects infest the growing crop and at harvest are brought with it into store, where they continue their development. More usually stored produce becomes infested by insects occurring in the structure of a store, in residues of old crops, from other infested commodities stored nearby, or from the use of infested sacks during transport. Storage places should therefore be thoroughly cleaned before intake and any insects present in a commodity should be eliminated at the beginning of the storage period. The usual method of dealing with insect infestation is to treat the commodity with chemicals; this may be done with fumigants or contact insecticides. Alternatively, airtight storage may be used.

Chemical treatments

26. Fumigation involves treatment of the commodity with a gas which is toxic to insects. The choice of fumigant which can be successfully used for disinfestation of commodities in bulk is limited by the difficulties of achieving a satisfactory distribution of the gas through the bulk.

27. Certain liquid fumigants, notably mixtures of ethylene dichloride and carbon tetrachloride can be added continuously or intermittently to a stream of grain entering a bin and in certain circumstances they can also be used successfully in a surface application to the filled bins or to bulks on the floor of a closed store.

28. Phosphine, released from specially formulated tablets containing aluminium phosphide, is also widely used as a fumigant for bulk grain. The tablets must be evenly distributed through the grain either by addition to a stream or by introduction through hollow probes.

29. Methyl bromide, which is widely used as a fumigant for bagged or packaged commodities is difficult to apply successfully to large deep bulks unless there is provision for mechhanical circulation of the gas through the grain. However, it has been used for shallow bulks e.g. in floor heaps under sheets by vapourisation above the surface without circulation.

30. Effective fumigation, while killing all insects present in the grain, offers no protection against re-infestation and it is essential that precautions be taken to avoid new infestations. Methods of achieving this in bins are the use of insect-proof manholes or the application of a contact insecticide to the top layer of grain.

31. The alternative to fumigation is the use of contact insecticides. In large storage installations this may be done by mixing a very dilute insecticidal dust, e.g. malathion or lindane, with the grain as it enters the bins. Another technique using these dusts is a "sandwich" treatment where the insecticide is applied at suitably spaced intervals to layers of grain in bins. Recently, techniques of spraying grain with liquid applications of such insecticides as synergised pyrethrins and malathion have been developed; the advantage of the spraying methods is that there is no problem from air-borne dust. Treatments with contact insecticides to be effective should either kill the existing infestation, or at least stop breeding of the insect pests and provide for the further protection of the grain from reinfestation during its subsequent storage.

Airtight storage

32. Since insects require oxygen for their respiration they will die if deprived of air. Advantage of this fact is taken in airtight storage (8) where infested dry grain is stored in an airtight container - the insects consume the oxygen within the container and die from lack of oxygen. The heavier the infestation the quicker will the insects be killed; in very lightly infested grain the insects will breed but the second generation will be large enough to deplete the oxygen. Damage due to microorganisms which require oxygen can

(8) Agricultural Research Council. The airtight storage of grain, Annu. Rep. Agric. Res. Coun. 1959 - 60, (1961).

can also be prevented by this method of storage; it should be noted that in grain of high moisture content adverse changes take place which do not occur in grain of low moisture content stored in an airtight container. A container for airtight storage must initially be filled to capacity to keep the free space to a minimum.

33. A common design for an airtight storage structure is an underground or semi-underground pit. In the Argentine (9) for example, concrete pits up to 150 ft long, 40 ft wide and 20 ft deep are used. The walls extend slightly above ground level and were originally roofed with bitumen-felt bonded to the walls; permanent concrete roofs are now fitted. Pits of similar design have been used with success in Tanganyika (10) for the storage of a famine reserve of maize. An experimental pit at the Pest Infestation Laboratory, Slough (11) has given excellent results with maize stored for five years.

34. In Cyprus airtight bins are being used with success (12). These consist of cone-shaped concrete pits, about 30 ft deep with a domed roof. The dome is formed by applying mortar to sacking which in the constructional phase is supported by a timber framework. The pit and roof incorporate an efficient waterproofing layer.

35. When considering bins for developing countries, cost is of prime importance. A relatively cheap airtight bin can be constructed on a suitable circular waterproofed foundation as follows; a cylinder of spot-welded steel mesh is stood on the base and hessian tied to the inside, the cylinder is then filled with grain. The outside of the structure is then plastered with cement mortar. The roof is constructed by applying cement mortar to hessian temporarily supported on a timber framework; entry is by a suitably gasketed manhole at the apex of the bin. The bin is rendered waterproof by coating with bitumen.

36. Some experimental work has been carried out at the Pest Infestation Laboratory on airtight containers constructed from plastic materials. One of these was a bin whose walls were constructed of panels of glass-fibre/polyester resin, the top and bottom being sheets of a flexible plastic, neoprene-on-nylon. In this bin was stored wheat which was artificially infested with insects at the time of loading; this infestation died out in three weeks as a result of the hermetic conditions in the bin, and the wheat

(9) Argentine Ministry of National Economy. Storage of wheat in underground silos, Proc. U.N. Sci. Conf. Conserv. & Utilization of Resources, Lake Success, 1949, 6, 356 - 358 (1951).

(10) Swaine, G., Underground storage of maize in Tanganyika. East Afr. agric. J., 20, 122 - 128 (1954).

(11) Hyde, M.B., et al., Underground storage of grain, Pest Infest. Res. 1960, (1961).

(12) Oxley, T.A., et al., The new grain bins in Cyprus, Colonial Office, London (1960).

was then satisfactorily stored for a year (13). Another container took the form of a pillow which was constructed of a coated material, PVC-on-nylon in which maize was satisfactorily stored for ten months (14). These containers are shortly to be tested in the tropics. The materials used to construct such containers are at the moment somewhat costly and the possibility of using cheaper materials is being investigated.

37. With airtight storage no chemicals are required for the control of insects, an important factor when one has to bear in mind that tainting and contamination must be avoided. The chemicals used for the control of insects are toxic to man in varying degrees and recommendations for their safe use by operators must be observed. In many developing countries the use of chemicals may be limited, apart from costs, by the low educational standards which exist; in these circumstances airtight storage is a safe form of storage which could perhaps be practised more widely.

(13) Burrell, N.J. et al., Tests with a glass-fibre bin, Pest Infest. Res., 1961 (1962).

(14) Burrell, N.J. and Ashwell, F.J.E. Tests on a flexible plastic tank, Pest Infest. Res. 1961 (1962).

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.4.3

United Kingdom

PRESENT AND FUTURE DEVELOPMENTS IN BULK STORAGE OF PRODUCE

By F.N. WRIGHT

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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Present and future developments in bulk storage of produce

by F.N. Wright

Storage in bags and bulk are briefly compared. The main advantages of bulk storage are the saving of time and labour, also, less storage space is required.

In order to store produce without deterioration it must be dried either by means of the sun or by artificial means. The relationship between the moisture content of a commodity and the relative humidity of the air is important in determining the level of moisture content at which a commodity can be taken into store; safe levels of moisture content will vary according to whether the produce is to be stored in a temperate or tropical climate.

Regular checks are necessary during the storage period to detect any deterioration due to translocation of moisture and the development of fungi or insects Methods of detecting deterioration include measurement of moisture content, temperatur carbon dioxide production by insects and finding of insects.

Traditional storage structures for flat and upright storage are considered. Generally, bulk storage is in bins. Their design and materials available for their construction are described. In designing bins lateral pressures which determine the strength requirements of the walls must be known.

For commodities other than grain special attention has to be paid to handling processes to avoid breakage. For a brittle commodity such as cocoa beans specially designed silos incorporating baffles or slides are necessary. Bins must be waterproof, special attention being paid to the foundations to prevent water being transmitted from the soil to the stored commodity. Bins should at least be rodent-proof and preferably insect-proof. A desirable feature is that they should also be gastight to enable fumigation to be carried out.

New types of storage structures are described. When storage facilities are inadequate as when excess harvests are produced interest is currently being shown in 'airhouses' which are buildings constructed of flexible plastic materials, their shape being maintained by blowing air into them. Structures supported by pneumatic arches are also currently being examined. The use of such plastic buildings would add flexibility to existing storage systems.

Bulk storage is largely confined to the cereal grain, one of the reasons for this is that the grain trade is large enough for special grain ships to be devoted to transportation of grain. Few other commodities could be shipped in similar

quantities and it is not easy to subdivide holds for several commodities whose quantities vary on each shipment. The possibility of transporting commodities in semi-bulk containers is examined. The advantages of the use of containers are the time and labour saved during loading and unloading. These containers could be insect proof, insulated and gastight. If filled in the producing areas there would be a reduction in the damage to commodities by insects; the use of containers could eliminate conventional bag-storage premises.

Methods for controlling insect infestations are discussed. The most usual method is chemical treatment including fumigation or the use of contact insecticides. An alternation method is airtight storage where infested dry grain is stored in an airtight container, any insects present eventually drying when they have depleted the oxygen. Airtight pits used in the Argentine and airtight bins used in Cyprus are described. Two experimental plastic, airtight containers are also described.

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Agenda Item: D.3.3

United Kingdom

STANDARDS AND ENGINEERING EFFICIENCY

By G. WESTON,
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D.3.3.

STANDARDS AND ENGINEERING EFFICIENCY

by G. Weston, O.B.E., Associate Director, British Standards Institution

1. Engineering tends often to be looked at very narrowly as the part of industry that makes or uses factory plant and equipment such as machine tools, boilers, turbines, electric motors, cranes, steel sections and the like. But in fact some aspect of engineering enters into every activity of industrial and commercial life and increasingly into agriculture and the exploitation of natural raw materials. Engineering efficiency in its widest sense is of vital importance to the development of any country even though that country may have little interest in producing any elaborate or complicated items of engineering equipment. But it will certainly need much engineering equipment for the economic functioning of its local industries, for production of building materials and the construction of factories. It must also develop its transport, its roads, its communications and its power supplies, exploit its minerals or timber, and ensure the quality of its exports to pay for the capital equipment it imports. All this means engineering, and to operate efficiently in this field, as well as to profit from the engineering experience of others, demand standards.

2. The value of standards as one of the indispensible tools in engineering is generally accepted as self-evident, but it is necessary to emphasize that as for any other tools, their nature and use has to be studied and learned. Standards are often complex documents both to prepare and to use. They may classify materials, define a range of qualities or grades, lay down how to test them and assess the results, or specify the dimensions, performance and ratings of components and machines, and the maintenance and operation of equipment. Their value depends largely on their wide acceptance and whilst themselves a disciplining factor their use requires industrial, indeed national, discipline.

3. The wide scope of activities in the economy of any country into which engineering enters underlines the importance of the adoption of common engineering standards and practices as a national policy. Government departments placing orders abroad and at home for materials and equipment, individual firms or public authorities manufacturing and providing services, will benefit from standards in their own sphere, but

common standards will bring the still wider benefits of interchangeability, a common technical shorthand and an integrated industrial economy ensuring effective use of national resources of raw materials.

4. The setting of standards for the products of any country - whether they be processed or natural products is of great importance in providing targets as a means of encouraging the general improvement of the quality marketed. Indeed some countries are adopting the policy of fixing higher standards for their exports than for home production and are taking steps to ensure that the products exported do in fact comply with such higher standards.

5. Engineering standards have been produced in all the highly industrialized countries of the world for many decades. They are constantly being reviewed and revised to keep abreast of progress and new standards are introduced as new materials and techniques are developed. The perennial problem is to know at what stage in a rapidly developing industry, such as electronics, to set the standards which will determine the design of equipment, or when a change in a well-established standard is called for because of changes in techniques or the uses to which materials and equipment are put. A country setting about the task of establishing national standards at any point of time will have to resolve similar problems even if it uses, as it will obviously do, the material available in other countries' standards and in internationally agreed recommendations. It will have to select what is appropriate to its own conditions (whether of climate or industrial skill), the range of types, sizes and qualities to be used or manufactured.

6. In addition it will have to institute or expand its research and testing facilities in order that the special problems of its production and use of materials can be investigated, and in order that testing of materials and products can be carried out to ensure that they are of the required quality, accuracy or other characteristics. The results of research and investigation can best be used and disseminated to producers and users of materials and products through the medium of standards of national application. For the basic equipment for testing and research, and for the methods to be used, guidance can be drawn from existing standards and international recommendations.

7. If the implementation of standards is to be effective they must be drafted along lines which will secure full acceptance on the part of those who are to use them, whether as manufacturers or purchasers. Hence the procedure for preparing standards which is generally adopted by standards organizations throughout the world is that of forming representative technical committees to be responsible for drafting and of seeing that opportunity is given to all interests to comment on the drafts before they are finally adopted as national standards.

8. This means that the organization required, whether functioning as part of a Government Department or independently, is one which will effectively represent producing and using interests, those concerned with Government and other public services and the technical advisory services which are available.

9. Even with general co-operation in the formulation of standards, there is still much to do done to secure their full adoption. Should they be imposed by law or their use be left to the good sense of purchaser or producer, reinforced by persuasion and publicity measures? Making standards obligatory is on the face of it very attractive and is certainly desirable in cases where safety or health are at stake: no one would question that standards for the protection of dangerous machinery and for the protective clothing of workers in dangerous occupations should be imposed by law. But for the rest, there are serious disadvantages in requiring compliance with the whole complex of national standards. The effect is almost inevitably to draft minimum standards, and to induce inflexibility, since legislative amendment of standards tends to be slow. Moreover the dilemma arises that obligatory standards, if not policed, will fall into disrepute or if policed adequately will impose an excessive burden on the economy. Some compromise therefore needs to be reached, and a decision made as to the standards which it is desirable, and economically practicable, to enforce. In any event everything is to be gained by making all those who use standards recognize that they have a responsibility to support and collaborate with the national standards organization. To ensure this, resources are required for publicity, information and technical services, as well as for advice and help in applying standards in the individual firm or organization. Most standards bodies recognize this and have expanded their functions, originally limited to the preparation of national standards, to include a wide range of services directed to the efficient application of standards.

10. The use of engineering standards as a means to simplification and good order is of major importance to countries whose trained personnel is severely limited in relation to the immense tasks to be tackled when a high proportion of income is being devoted to capital development. The more tasks that can be reduced to routine through reference to accepted specifications, the more time is available for special design and operational problems. Standard equipment means less supervision, less improvisation, less trouble with ordering, replacement and servicing, and a wider field for competitive purchase as supply is not limited to a single firm. From the financial point of view, the standard product should be cheaper to produce and to purchase, and the capital cost of holding stocks can be reduced. Haphazard development of costly installations and the consequent expense of maintenance, modification and the problems of expanding the installations will be avoided.

An important financial saving accrues from the proper use of materials indigenous or imported - based on standards which can provide exact guidance on the types and grades to be used for different purposes, so that equipment and products are neither over nor under-engineered.

11. The fundamental engineering standards are not only means of simplifying and unifying practice but, as already developed nationally and internationally, provide invaluable text books to guide production and engineering services. They illustrate the range of subject matter which can be covered by standards. First there are the standard terms and definitions, symbols and conventions for drawing practice, limits and fits: all these when adopted within a manufacturing or operating unit, and in a country's engineering as a whole, will immensely simplify the understanding of technical specifications on the factory floor, in the setting up of a plant, in tendering to meet contracts, and in the interchange of technical information in purchasing. At the international level - and there is already fairly wide agreement on the details of drawing practice and on the definition of limits and fits - the exchange of technicians, the work of consulting engineers and the supply of plant from different oversea sources will be simplified if a common engineering language is used.

12. Standard methods of test for basic engineering materials-steel, non-ferrous metals-are the next basic requirements, to secure consistent quality and suitability for the purpose to which the materials are to be put. Such standards may also have to deal with sampling procedures and to specify test apparatus. Specifications setting the appropriate limits of performance, in relation to such tests for particular end-uses, complete the data required on materials. Here again international agreement is already considerable.

13. Components in wide general use - fasteners, shafts, jigs, related spanners and tools - all demand common national standards if waste and dislocation are to be avoided. In the case of fasteners, the international picture is of two basic screw thread systems - the ISO (Unified) inch thread, and the ISO metric thread for which standards are now in process of preparation. The difficulties arising from these two systems can be exaggerated, since both have the same thread profile and moreover the nut and bolt in machinery are supplied as a single item, but in any country the eventual aim should be to work on a single system. As things stand, however, with the vast use of both inch and metric threads throughout the world, it would be unwise to adopt so rigid a national policy as to cut off supplies from sources using either the one system or the other.

14. Standards for essential dimensions (for functional interchangeability) and performance of more complex, but widely used engineering equipment (whether produced locally or imported)-electric motors and cables,

machine tools, form another group of basic standards. Here the choice of types, ranges of sizes, ratings etc., is important and the greater the simplification the better, provided there is a reasonable choice within the national standard and the designer is not forced to introduce haphazard variations. Excessive restriction of types may also reduce the element of competition in design and prevent development. It is clear however, that subject to this, the minimum of types and sizes leads to longer manufacturing runs, with consequent economies, better control of quality, less wastage of material, savings in packaging, warehousing stockkeeping and administrative procedures.

15. The final group of standards affecting the general running of engineering industry is that of codes of practice. The benefit from standards which provide for equipment of good quality can be entirely defeated it it is treated in the wrong way. This can be avoided by working to Codes of Practice which lay down standard procedures to be adopted, for example in the installation and maintenance of machinery such as transformers and rectifiers, in the operation of boilers, for identification of pipe lines in the factory, in packaging methods, and in materials handling.

16. A major factor in the efficient running of engineering industry is the confidence of the worker in the safety measures adopted and the steps taken to avoid accidents, as this has a significant effect on his individual output. This confidence will be secured not only by the application of appropriate standards of quality, reliability and safety, to the equipment, machines and tools used such as lifting gear, chains, hooks and slings and hammers or other hand tools, but also by specific standards for safety equipment worn and used by personnel and by safety codes and symbols. Examples are standards for industrial helmets, protective goggles for welding, gloves for electricians, safety boots, together with standard symbols and colours to indicate danger of various kinds.

17. National Standards, then, should be the source of information and guidance on materials and equipment, procedures and practices of the many kinds described, for the individual engineering firm or contractor. These standards must necessarily specify a wider range than any particular manufacturing or operating unit requires, and intelligent and careful selection is necessary for the particular jobs to be done. Selection from a common basis will, however, ensure the advantage of interchangeability between the products of one firm and another and understanding between the firm and its suppliers and customers.

18. This "intelligent" selection from national standards and their application to the requirements of any particular firm or organisation is an important task. It is increasingly recognized in engineering

industry, therefore, that whatever the size of unit there must be a department or individual responsible for settling the firm's standards, based on the national standards. This department or individual should work in close consultation with the departments responsible for design, production, purchase of materials and stores, selling and general administration. The "Standards Engineer" is becoming an accepted category in the engineering world and, within the general lines of policy on what is to be produced or the services to be provided, he will keep a watch on the range of standard products, the cataloguing of parts designed or "bought in", the changes in national standards affecting the company standards which have been laid down and will scrutinize demands for variations from designers and others. Without the rigorous discipline of a standards department or standards engineer there is always a tendency for unnecessary diversity to creep in, for components used by different branches of a concern to be separately specified and ordered, perhaps under different names, and for parallel stocks to be built up, with all the waste of administrative effort, in purchasing, recording and store-keeping.

19. The adoption and application of standards in engineering has so far been considered in its more general aspects, and while emphasis has been laid on the need to master the use of these tools for greater efficiency, the crucial problem of ensuring compliance with specifications on the production floor remains to be considered. A standard sets the precise level of quality reliability or accuracy or dimensioning of the product and must do so in such a way that every one concerned with its achievement can be in no doubt regarding the level which must be reached. The objective of the purchasing firm must be to achieve the requisite quality at minimum cost and to be able to demonstrate to its customers that the quality is consistently achieved. (To play safe by exceeding the quality laid down makes sense neither economically nor technically: too high a quality will not only be expensive but may cause difficulties to the customer because the material will damage or wear out his tools). A standard which not only specifies the quality but also the methods of testing to be employed, the sampling rates and inspection procedures will help the firm to secure these objectives. Standards of this kind, based on sound statistical techniques, are increasingly being developed, particularly as automatic methods of manufacture are adopted.

20. Such standards will indicate the limiting values - e.g. of tensile strength or sulphur content of steel - and also the average values, which it is important for the user to know. They will recognize the inevitability in economic quantity production of a percentage of defectives - if, for example, a product of tensile strength not less than a standard specified value is being produced consistently and without fail, it is almost certain that the target value in the production process has been

set at too high a level or alternatively that the limiting value has been specified at too low a level. The permitted percentage of defectives will vary according to the use for which the material is designed, but with manufacturer and customer in agreement both on the standard of quality and the quality control procedures to be followed, disputes will be avoided. When of course 100 per cent compliance with specified quality is demanded, for items crucial to safety, standard methods of sampling must be replaced by 100 per cent inspection and testing but in large areas of engineering, sampling methods, allied with inspection at crucial stages in manufacture, will be sufficient. Quality control, based on sound standards, will not only help in satisfying the customer, but will also provide the manufacturer with a valuable aid in increasing the efficiency of his production processes.

21. What has been said so far relates to standardization in the national sphere, though some reference has been made to the international recommendations which have been issued - and this work is going on all the time - on engineering standards, Differing national standards can be a most serious barrier to international trade. International co-operation in the alignment of standards has the possibility of yielding great returns. It is as essential to the developing countries as the other forms of international co-operation tor spreading technical knowledge, providing skilled technicians, and providing financial resources and capital equipment. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (I. E. C) are currently responsible for nearly 200 Technical Committees, many of them concerned with engineering, with raw materials and their testing, with building construction and with the equipment and operation of international services such as air transport and communication on which international trade and co-operation depend. The outcome of this work is agreed recommendations to govern the content of national standards, and these already cover a wide field: pipes and fittings, ball and roller bearings, gears, pulleys and belts, machine tools, petroleum products, steel, light metals, rubber and plastics, all types of electrical equipment, aircraft components, airport service requirements. Surveys of national practice have shown the very large extent to which ISO and I. E. C Recommendations are being followed by the countries which aremmembers of these organizations. As in the case of companies using national standards, so the national body must select - and perhaps supplement - the basic specifications laid down by international agreement, but by using them for purchasing and production a country will enlarge its sources of supply, will be able to compare the equipment it is offered and test it on a reliable and uniform basis, will secure a co-ordinated development of its capital equipment and more readily secure acceptance of its exports in world markets.

22. Any country that is developing its economy cannot fail to benefit by co-operation in the work of the international standards organisations and by adopting the internationally agreed recommendations. Valuable as is the experience and research that goes into the preparation of national standards, the collective knowledge that is available in international standards and the wide agreement on practice and techniques that they represent make them indispensible as guides to national standards policy.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.3.3

United Kingdom

STANDARDS AND ENGINEERING EFFICIENCY

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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STANDARDS AND ENGINEERING EFFICIENCY

1. Engineering efficiency is of major importance to all aspects of economic development, whether in engineering production itself or in exploitation of raw materials, in agriculture, and public services. Standards are required for an efficient economy and as the means of profiting from engineering experience. The use of standards, as of other tools in industry, has to be learned. They cover qualities and grades, methods of test and assessment of results, dimensions, performance and ratings, maintenance and operation of equipment. Their value depends on wide acceptance. Hence the need for the adoption of engineering standards and practices as a national policy to ensure an integrated industrial economy, interchangeability of components and machines and effective use of raw materials.

2. Engineering standards are firmly established in the highly industrialized countries but are not static; they are under constant review as new materials and techniques are developed. A country deciding upon its own national standards can use much of the material available in other countries standards and in international recommendations but will have to select what is appropriate to its own conditions. Facilities for investigation of technical problems and for testing will be required in establishing standards and in ensuring compliance with them.

3. Effective implementation of standards requires that they should be so drawn as to command acceptance from manufacturing and using interests. Accordingly the standards organization should be such as to enlist co-operation in the preparation of standards from all interests. To make all standards obligatory by law, as a means of implementation, has serious disadvantages: it tends to result in minimum standards and in inflexibility; if obligatory standards are not effectively policed they will fall into disrepute, while the cost of enforcement may be uneconomic. Certain standards, however, - particularly those for safety - are rightly made obligatory. To ensure voluntary adoption of standards generally resources will be required for publicity.

4. The use of standards conserves resources of man-power and materials by reducing many tasks to routine, by reducing the amount of supervision required, by facilitating ordering, replacement, servicing and holding of stocks and by the economic utilization of the appropriate grade of material.

5. Existing fundamental standards for engineering provide invaluable text books e.g. on terms and definitions, symbols, and conventions for drawing practice; they provide a common technical language in the engineering plant, in purchasing and tendering and in exchange of technical information.

6. Methods of test for basic engineering materials, standards for components in wide general use and for essential dimensions and performance of general engineering equipment, codes of practice for installation, maintenance and transport - these form the main groups of standards to be established and introduced. The range of types and sizes of components and equipment to be specified should be the minimum compatible with reasonable choice.

7. In the efficient running of engineering industry a major factor is the confidence of the worker in safety measures. This confidence will be secured by the use of adequate and consistent safety standards for equipment, machines and tools, for personal protective clothing, and for symbols etc. warning of danger.

8. The individual undertaking will select from national standards those required for its own purposes; this task, within the framework of its general policy, should he be assigned to an individual "standards engineer" or standards department, working in consultation with the design, production, purchasing and selling departments.

9. The consistent achievement by the engineering firm of the level of quality and accuracy of dimensioning required by the specifications to which it will manufacture and sell can be facilitated if the standards themselves lay down the methods of testing, the sampling rates and inspection procedures. This will minimize disputes about defective products. In some cases, for items crucial to safety, 100% inspection and testing will be required.

10. International standards agreement, aimed at removing the barriers to international trade, international services and technical co-operation, already covers a wide range of engineering activity. The recommendations of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) are designed to form the basis of national standards and the many recommendations already issued have been widely adopted by the member countries. Their adoption enables a developing country to enlarge its sources of supply, to compare tenders on a uniform and competitive basis and more readily to secure acceptance of its exports in world markets.

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Agenda Item: D.8.1

Canada

ORE MICROSCOPY AS A GUIDE TO ORE DRESSING PROCEDURE

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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ORE MICROSCOPY AS A GUIDE TO ORE DRESSING PROCEDURE

No.260
D.8.1.

by

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1. Definition of Ore Microscopy

Since its first modern application more than fifty years ago[1], ore microscopy has become not only an important branch of mineralogy, but has also proven itself indispensable in the fields of mining geology, mineral processing and extractive metallurgy. In a strict sense, the term "ore microscopy" refers only to the examination of opaque minerals in polished sections under the reflecting microscope. In modern practice, however, it implies much more. Now the importance of the transparent gangue minerals in metallic ores is recognized, and the growing significance of such elements as niobium and beryllium requires that the transparent minerals in which they occur be studied in detail. Then too, we are faced with diminishing mineral resources and consequently with the necessity of exploiting deposits that are mineralogically complex and hence difficult to treat. This has resulted in the use of several other techniques supplementing the microscope. For instance, X-ray powder diffraction methods are used for the identification of the minerals and the recently developed electron probe micro-analyser is most helpful in determining the distribution of the elements among the mineral grains. However, in spite of these modern trends, the microscope itself remains the most useful basic means of learning the character of mineral assemblages. In this very brief summary of its use in the field of ore dressing, the strict meaning of the term "ore microscopy" will be adhered to closely.

2. Apparatus

(a) General statement: The apparatus required for ore microscopy will vary widely in complexity and cost, according to the need and the funds available. The references include many excellent descriptions of the apparatus and its uses. In general it is true that a minimum of apparatus essential for the microscopical examination of metallic ores will yield the greatest return on the investment, and that elegant and costly accessories should be avoided unless they are needed for special cases.

(b) Polishing apparatus: The preparation of polished sections may be either a simple or a complicated procedure. Solid sections of ores can be prepared very simply by hand-polishing the unmounted specimens on relatively inexpensive machines[2, 3]. Fragmented samples, such as mill products, require mounting before polishing, and since their study cannot be avoided in connection with ore dressing, a means of mounting must be provided. Some ores are soft and friable and their preparation is extremely difficult and involves impregnation with special resins. In fact, the preparation of polished sections is a highly skilled craft and minerals vary so greatly in physical character that it is not surprising that the methods for polishing ores also vary in detail[2, 3, 4, 5, 6]. Basically however, the minimum of equipment required includes a rough grinding lap for shaping ore specimens, facilities for mounting ores and mill products in plastic[7, 8], and polishing machines fitted with either metal or fabric-covered laps[2, 3, 4, 5]. More elaborate installations would include a precision diamond saw, semi-automatic polishing machines and many other accessory devices.

(c) Microscopical apparatus: The most important requirement for ore microscopy is a modern reflecting microscope of highest quality. Accessories can be added as required. A microscope that can be converted to a petrographic microscope by using an additional tube and sub-stage is highly desirable. There should be at least three air objectives for low, medium and moderately high powers of magnification, and a good high power oil immersion objective. Many additional accessories may be required for special purposes such as photomicrography, statistical grain analysis and measurement of reflectivity, but a good microscope equipped with objectives covering a wide range of magnifications and having a micrometer ocular and traversing stage for grain analyses, will be found to be adequate for many purposes.

3. The Microscopical Examination of Polished Sections

(a) General statement: The microscopical examination of polished sections of ores and mill products must be done by trained personnel. It will be apparent, after referring to any of the standard works on the subject, that especially the interpretation of mineral textures and their correlation in terms of milling behavior require training and experience.

(b) Identification of minerals: The identification of the minerals in polished sections under the reflecting microscope is based upon their optical, physical and chemical properties[4, 9, 10, 11, 12, 13]. Optical properties include colour, brightness (reflectivity), anisotropic effect and the character of any internal reflections. Physical properties are hardness, sectility, crystal habit, cleavage or parting, and zoning as reflected in systematic fracturing and pitting. Chemical properties that can be observed under the microscope are normally restricted to surface reactions brought about through the application of etching reagents[12]; this also tends to display any zoning due to changes in chemical composition. Microchemical tests[12] are sometimes very useful and although most of the common minerals can be recognized readily in polished

sections after some experience, positive identification of minerals in complex and fine-textured ores is frequently difficult. If such ores are encountered, it may be necessary to employ some of the supplementary techniques mentioned earlier in paragraph 1, for the identification and characterization of the minerals.

(c) Form and texture: The form and texture shown by minerals and the manner of their mutual association[4, 14, 15, 16] are the basic guides to ore dressing procedure. The minerals are the units, and the ore dressing engineer has to separate the valuable constituents from those that are worthless. Therefore, their grain sizes, physical characteristics and the degree to which they are combined with one another will determine the extent to which grinding must be carried to effect their separation.

(d) The examination of mill products: The examination of mill products in conjunction with ore dressing procedures, either in testing laboratories or in operating mills, is indispensable, particularly when difficulties arise in separating the minerals. When the significant products are studied microscopically, the cause of the trouble is usually quite apparent. It is advisable to study the solid ore sections before the examination of mill products is attempted, because the minerals can be more easily identified in the larger grains of the solid ore than in the smaller fragments. In fact the study of ore prior to its test treatment can frequently save the engineer many hours of testing, and in some instances the behavior of the ore can be forecast with remarkable accuracy. In operating mills it is advisable to use a binocular microscope, because the experienced engineer can tell a great deal about the functioning of the circuits by examining the products.

(e) Grain analyses: Grain analyses can be very useful in ore dressing operations. Several methods have been used for ascertaining the relative quantities of the minerals in ores and mill products[2, 4, 17]. Sometimes very complete statistical studies have been made to determine the degrees of freedom and the combinations of the various minerals of a complex ore. Such studies, however, are ordinarily too fatiguing and time-consuming to be justified, and some thought is now being given to find a method of performing these analyses automatically through the use of modern electronics applied to the varying reflecting characteristics of the ore minerals.

4. Interpretation of Microscopical Data

(a) Gold ores: The interpretation of microscopic features in terms of ore dressing procedures is based on their correlation with the behavior of the ore under milling conditions. The relationship between mill practice and the manner in which gold occurs illustrates this rather clearly. If the gold occurs as comparatively coarse grains and veinlets in quartz (See Fig. I) or in sulphides (See Fig. II), satisfactory recoveries can be expected to result from comparatively coarse grinding and gravity methods of separation. If its average grain size is less (See Fig. III), the ore may require finer grinding followed by cyanidation to recover the finer gold. If sulphides are present, as they frequently are in the form of pyrite and arsenopyrite, some of the gold may be enclosed within the sulphides (See Fig. IV). If the inclusions are in

very dense sulphide (See Fig. V), the sulphides may have to be concentrated by flotation, re-ground and cyanided. When the average grain size of the gold in the sulphides is very small (See Figs. V and VI), recovery by cyanidation of the flotation concentrate may be negligible; in such cases the concentrates must be roasted before re-grinding and cyanidation. Fig. VI shows tiny gold particles in arsenopyrite; in this ore the arsenopyrite itself is very finely disseminated, and presents a problem in concentration. In fact, for this reason, the operation of the mine was on the economic borderline. It is probable that in some ores the gold is largely in sub-microscopic form, and possibly also in solid solution. The presence of interfering minerals, such as talc or other soft flakey minerals, may cause trouble. Chalcopyrite (See Fig. VII), as well as pyrrhotite, can contaminate cyanide solutions and cause trouble in the circuits. Acute complications are introduced when gold and silver tellurides, graphite, et cetera are present in appreciable quantities as shown in Fig. VIII.

(b) Iron ores: The beneficiation of iron ores requires treatment of very large tonnages by very economical methods. The coarse-textured ore seen in Fig. IX is easily treated by gravity and magnetic separators. On the other hand the ore shown in Fig. X is practically impossible to treat economically. A titanium-bearing ore, in which ilmenite, hematite and magnetite occur as separate, individual, relatively coarse grains, can be treated satisfactorily, but no amount of grinding can free the intimately admixed ilmenite-magnetite or ilmenite-hematite intergrowths (See Fig. XI) frequently found in titaniferous iron deposits.

(c) Base metal ores: Base metal ores show great variation in their characteristics and, hence, present a great variety of problems to the ore dressing engineer. Some are coarse textured and the minerals are comparatively easy to separate (See Fig. XIII), while others are fine textured and the minerals are so intimately associated that their separation is impractical, if not impossible (See Figs. XII and XIV). The reason for poor recoveries or incomplete separation of the minerals is usually apparent when the products are examined microscopically. Two examples are given in Figures XV and XVI, but numerous others have been recorded.

5. Conclusion

It must be remembered that metallic ores seldom even approach homogeneity in the distribution of the minerals. In fact ores commonly show very wide variations throughout a deposit, and each type presents a unique set of problems that must be solved before it can be treated satisfactorily. Ore microscopy is one of the most effective weapons in solving these problems and for guiding and improving ore dressing practice.

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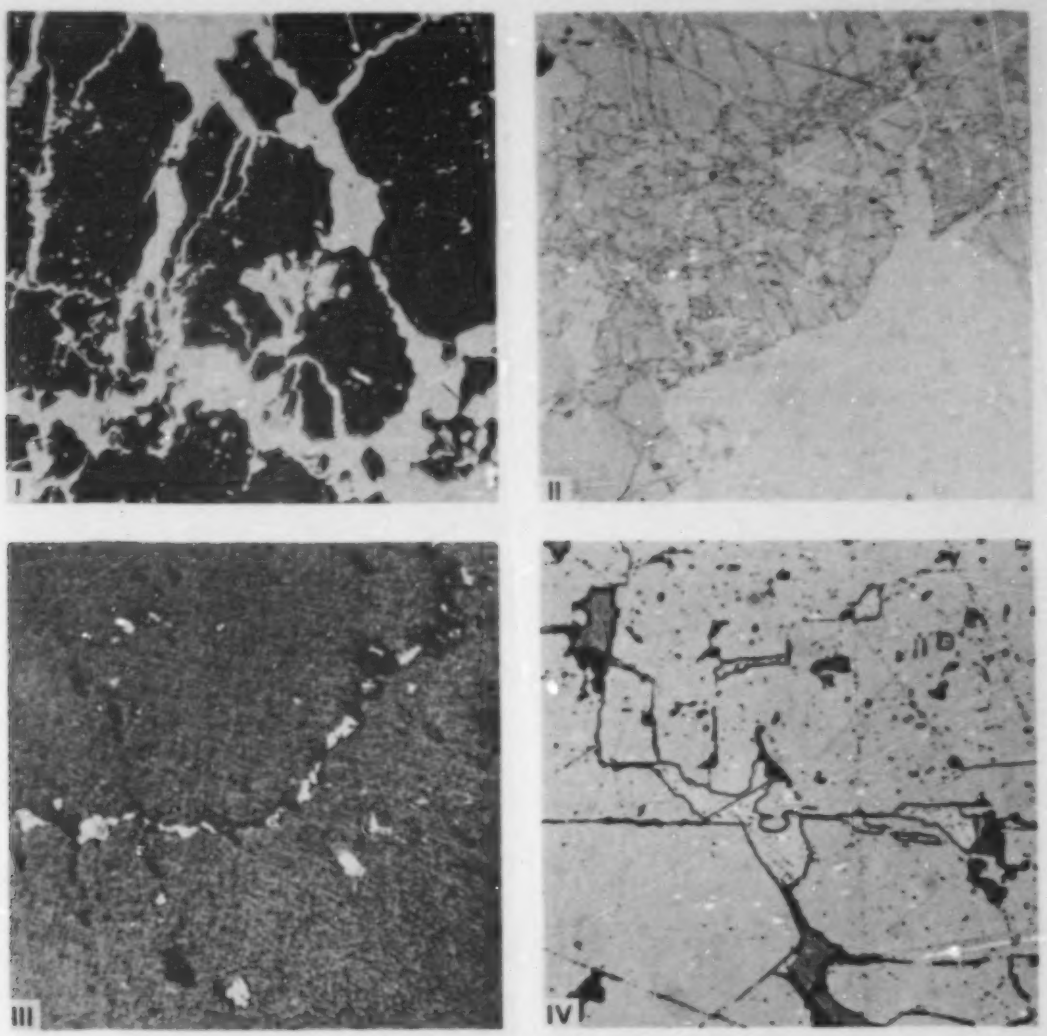


Fig. I Polished section of rich gold ore from Lake Shore Mine, Ontario. The veinlets of gold (white) in the quartz (black) are very easily freed and recovered by gravity methods. Magnification 50x.

Fig. II A very rich section of gold ore from the Bralorne Mine, British Columbia. Here the coarse gold is associated with arsenopyrite (grey). This type of gold occurrence presents no treatment problem. 50x.

Fig. III Gold in quartz from the Porcupine District, Ontario. This gold (white) occurs as much smaller grains, and treatment involves finer grinding and cyanidation. 100x.

Fig. IV Moderately coarse to fine gold (white) in pyrite (light grey) and quartz gangue (dark grey) from northern Ontario. The coarse gold is recovered by gravity methods, the finer must be recovered by cyanidation. 100x.

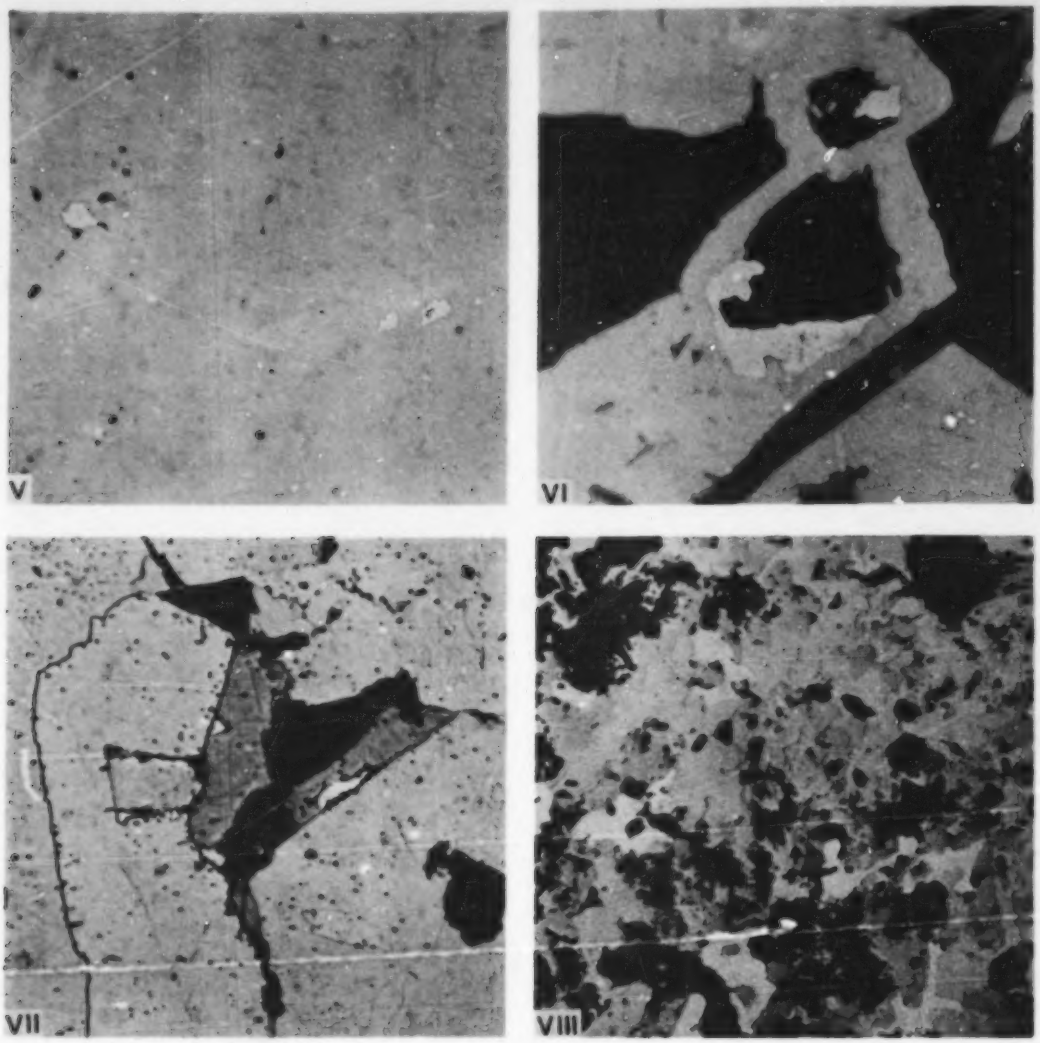
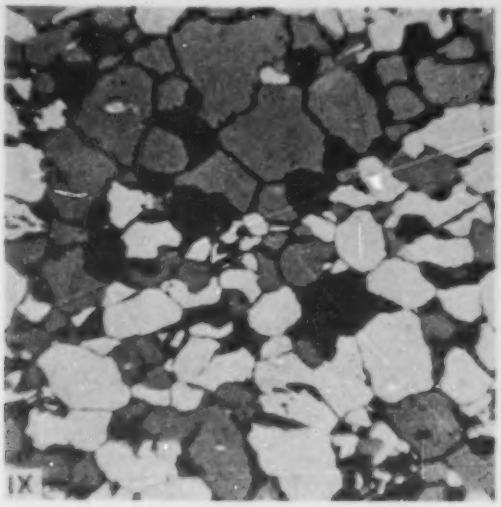


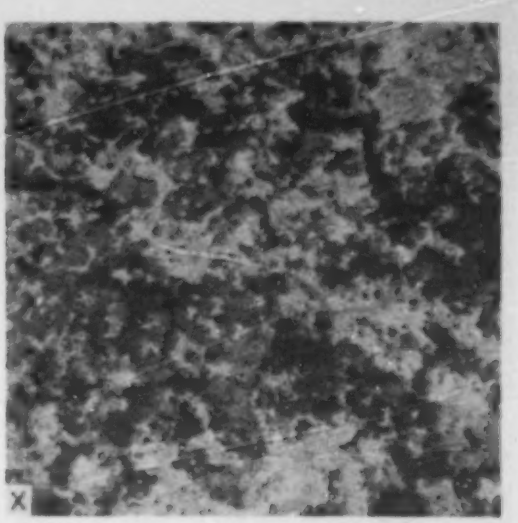
Fig. v Tiny grains of gold (white) in dense pyrite (grey) from northern Ontario. The sulphides are concentrated by flotation and cyanided after re-grinding. 1000x.

Fig. VI Tiny grains of gold (white) in skeletal crystals of arsenopyrite from Beattie Gold Mine, Quebec. The arsenopyrite must be concentrated and the concentrate roasted and re-ground before cyanidation. 1500x.

Fig. VII Tiny grains of gold (white) along the boundaries of chalcopyrite (dark grey), pyrite (light grey) and arsenopyrite (slightly darker grey than the pyrite). The black areas are pits. 1000x.

Fig. VIII A rich section of gold from Kirkland Lake, Ontario. Here the gold occurs with an assemblage of gold and silver tellurides, pyrite (varying shades of grey), graphite (not shown in this field) and quartz (black). This requires complex treatment. 500x.





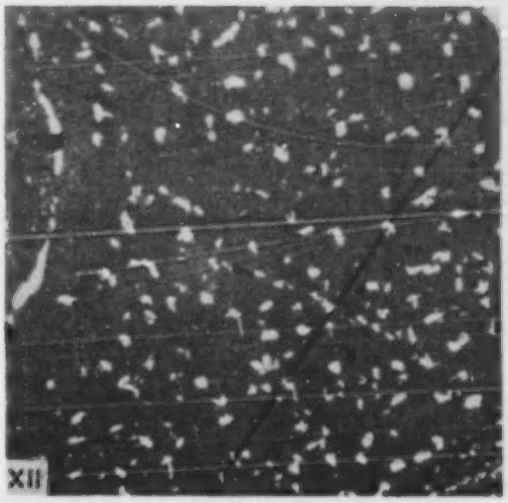
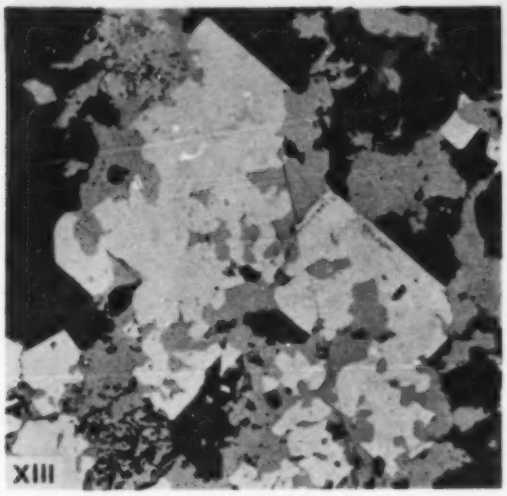


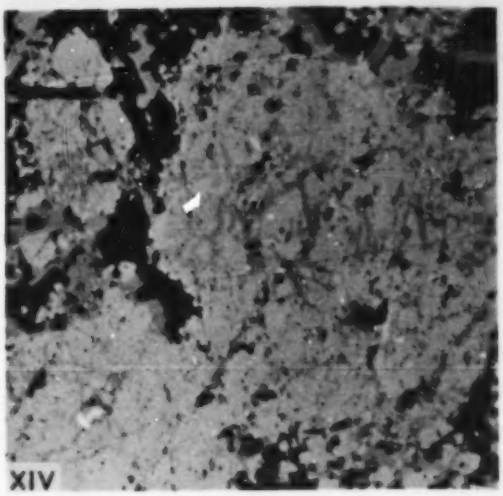
Fig. IX Iron ore from central Labrador, Newfoundland. Coarse magnetite and hematite (both white) in quartz, and carbonate gangue (grey). Pits are black. The iron minerals are freed from the gangue minerals very easily. 100x.

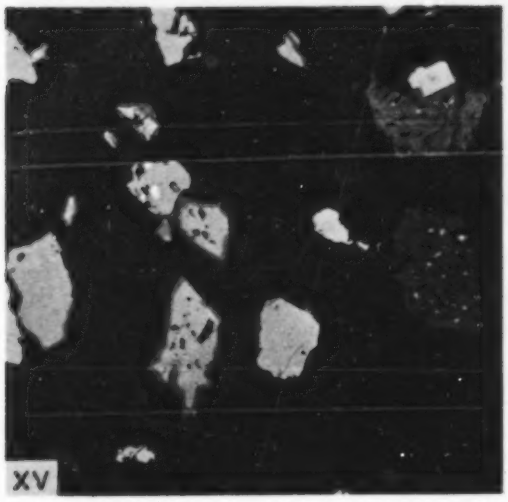
Fig. X Heavily oxidized iron ore from central Labrador, Newfoundland. The ore is soft and friable, and the minerals include goethite, hematite and silicates. Beneficiation is very difficult, if not indeed impossible by gravity methods. 1000 x.

Fig. XI Hematite-ilmenite intergrowth in an iron ore from Ontario. The hematite is white, the magnetite is grey. These cannot be separated mechanically. 1000x.

Fig. XII Numerous tiny exsolved inclusions of chalcopyrite (white) in sphalerite (grey) in a base metal ore from New Brunswick. It is obvious that the copper and zinc of this assemblage cannot be separated mechanically. 1600x.







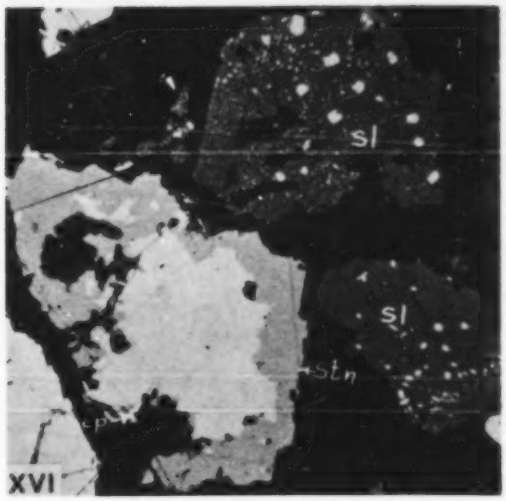


Fig. XIII Coarse-textured intergrowth of sphalerite (light grey) and pyrite (white, with cubic habit) in quartz (dark grey) from British Columbia. 50x.

Fig. XIV Pyrite (white) intricately veined by chalcopyrite (light grey) and associated with sphalerite (dark grey) and quartz (black). Copper-zinc ore from northern Quebec. 200x.

Fig. XV Combined grains in a flotation concentrate from a British Columbia mill. Chalcopyrite (light grey) rimmed by chalcocite and covellite (grey and indistinguishable from one another in the photomicrograph), and sphalerite (dark grey) containing numerous tiny dots of exsolved chalcopyrite, and in one instance still attached to pyrite (white). The mounting medium is black. 200x.

Fig. XVI Combined grains in a concentrate from a copper-tin ore from New Brunswick. Chalcopyrite (white - cp), stannite (light grey - stn) and sphalerite (dark grey - sl). The mounting medium is black. 1000x.

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19 Oct. 1962
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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.8.1

Canada

ORE MICROSCOPY AS A GUIDE TO ORE DRESSING PROCEDURE

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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ORE MICROSCOPY AS A GUIDE TO ORE DRESSING PROCEDURE

by

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Department of Mines and Technical Surveys, Ottawa, Canada.

1. A brief outline is presented of the use of ore microscopy as a guide to ore dressing procedure. Practical advice is given as to the apparatus and the technique of preparing and examining polished sections of ores. Photomicrographs illustrate some of the features of metallic ores. The works listed in the bibliography cover the field, and contain numerous references to the detailed literature.

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